Claims

[c1] A method for determining continuity of a material on a substrate, comprising:
depositing the material on the substrate using a first value of a growth metric;
depositing an amount of charge on a surface of the material;
repeatedly measuring a surface voltage of the material until an onset of tunneling to provide a Vtunnel value;
repeating the above steps for different values of the growth metric; and
comparing the Vtunnel values for different values of the growth metric to provide a measure of the continuity of the material on the substrate.

[c2] The method of claim 1, wherein the step of comparing the Vtunnel values further comprises:
determining a transition between a linear region and a non-linear region of the Vtunnel values, wherein the linear region corresponds to layer-by-layer growth of the material on the substrate, and wherein the non-linear region corresponds to islanded growth of the material on the substrate.

[c3] The method of claim 1, wherein the growth metric is selected from the group consisting of thickness, time, precursor cycles, and temperature.

[c4] The method of claim 1, wherein the material is deposited on the substrate using Atomic Layer Deposition (ALD).

[c5] The method of claim 1, wherein a fixed amount of charge is deposited on the surface of the material.

[c6] The method of claim 1, wherein the method is non-destructive and can be used in-line.

[c7] The method of claim 1, wherein the material is a high-k dielectric material.

[c8] The method of claim 1, wherein the step of comparing the Vtunnel values further comprises:
identifying optimum growth conditions for layer-by-layer deposition of the material on the substrate.

[c9] The method of claim 1, further comprising:
determining a growth mode of the material on the substrate.

[c10] The method of claim 9, wherein the step of determining a growth mode of the material on the substrate further comprises:

comparing a first derivative of a Vtunnel per growth metric curve versus the growth metric; and
examining a linearity of results of the comparison to determine the growth mode of the material on the substrate, wherein a linear region corresponds to a layer-by-layer growth mode of the material on the substrate, and wherein the non-linear region corresponds to an islanded growth mode of the material on the substrate.

[c11] The method of claim 1, further comprising the steps of:
dividing each Vtunnel value by a constant thickness value to provide an Etunnel value; and
comparing the Etunnel values for different values of the growth metric to provide a measure of the continuity of the material on the substrate.

[c12] The method of claim 11, wherein the step of comparing the Etunnel values further comprises:
determining a transition between a linear region and a non-linear region of the Etunnel values, wherein the linear region corresponds to layer-by-layer growth of the material on the substrate, and wherein the non-linear region corresponds to islanded growth of the material on the substrate.

[c13] The method of claim 11, wherein the step of comparing the Etunnel values further comprises:

identifying optimum growth conditions for layer-by-layer deposition of the material on the substrate.

[c14] The method of claim 11, further comprising:
determining a growth mode of the material on the substrate.

[c15] The method of claim 14, wherein the step of determining a growth mode of the material on the substrate further comprises:
comparing a first derivative of an Etunnel per growth metric curve versus the growth metric; and
examining a linearity of results of the comparison to determine the growth mode of the material on the substrate, wherein a linear region corresponds to a layer-by-layer growth mode of the material on the substrate, and wherein the non-linear region corresponds to an islanded growth mode of the material on the substrate.

[c16] A method for determining a growth mode of a material on a substrate, comprising:
depositing the material on the substrate using a first value of a growth metric;
depositing an amount of charge on a surface of the material;
repetitively measuring a surface voltage of the material until an onset of tunneling to provide a Vtunnel value;

repeating the above steps for different values of the growth metric; and
comparing a first derivative of a Vtunnel per growth metric curve versus the growth metric to determine the growth mode of the material on the substrate.

[c17] The method of claim 16, further comprising the steps of:
dividing each Vtunnel value by a constant thickness value to provide an Etunnel value; and
comparing a first derivative of an Etunnel per growth metric curve versus the growth metric to determine the growth mode of the material on the substrate.

[c18] The method of claim 16, wherein the growth metric is selected from the group consisting of thickness, time, precursor cycles, and temperature.

[c19] The method of claim 16, further comprising:
examining a linearity of results of the comparison to determine the growth mode of the material on the substrate, wherein a linear region corresponds to a layer-by-layer growth mode of the material on the substrate, and wherein the non-linear region corresponds to an islanded growth mode of the material on the substrate.

[c20] A system for determining continuity and growth mode of a material deposited on a substrate, comprising:

a system for depositing an amount of charge on a surface of the material;

a system for repeatedly measuring a surface voltage of the material until an onset of tunneling to provide a Vtunnel value; and

a system for determining the continuity and growth mode of the material using Vtunnel values obtained for different values of a growth metric.